

CIRPASTwin Otter



CIRPAS

UV-18A 'Twin Otter'

- Military version of the DeHavilland DHC-6
- Payload: 4500 lb
- Power: 6000W
 - 28V DC
 - 120V 60Hz AC
- Ceiling: 12,000 ft (25,000 ft with oxygen)
- Speed: $50 - 80 \text{ m s}^{-1}$ (50 m s^{-1} for aerosol sampling)
- RF Communications:
 - VHF, UHF, HF, UHF/FM
- SatCom (4800 baud)
 - Quick-look data available during flight

CIRPAS Twin Otter Objectives

- Characterization of air and aerosols that feed into convective structures
 - Particle size distribution and concentration
 - Aerosol chemistry
- CCN Closure
- Low level radiative flux measurements
 - Especially beneath anvil

CIRPAS Twin Otter Team

- CIRPAS: Haflidi Jonsson
 - Met/Nav instruments, GPS
 - PMS probes (PCASP, FSSP 100)
 - DMT CAPS probe
 - CPCs, Nephelometer, PSAP
 - Aerodyne Water Vapor
- Caltech: Rick Flagan, John Seinfeld
 - SMPS, Aerosol Mass Spectrometer
- University of Denver: Mike Reeves
 - MACS, Multi-sample aerosol collection system
- NCAR: Teresa Campos
 - CO (Water vapor)
- NASA Ames: Peter Pilewskie
 - Spectral and broadband radiometers

CIRPAS Twin Otter

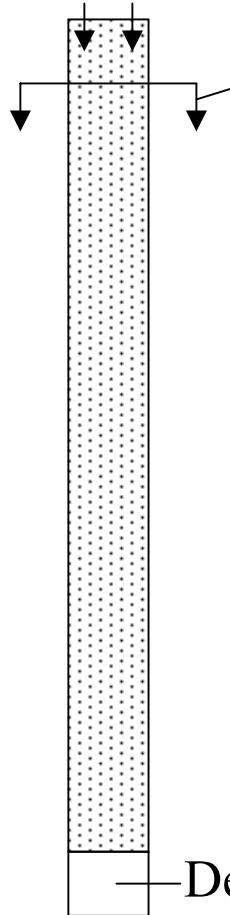
- Meteorological Data
 - Temperature
 - Pressure
 - Dew Point
 - Vertical velocities
 - Radome
 - 10 Hz
- Aerosol Optical Properties
 - TSI 3-color Nephelometer
 - Radiance Research Soot Photometer (PSAP)
- Location
 - GPS
 - Radar altimeter

Flight Data System

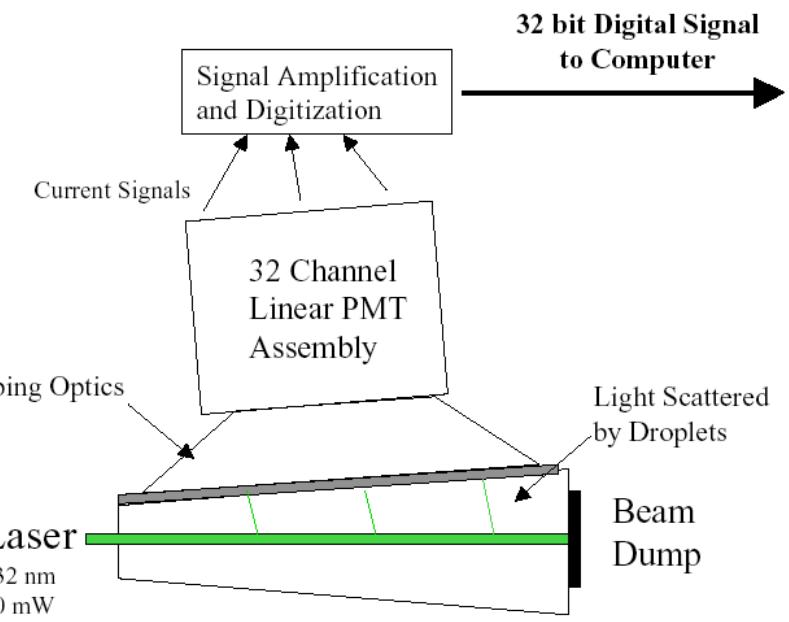
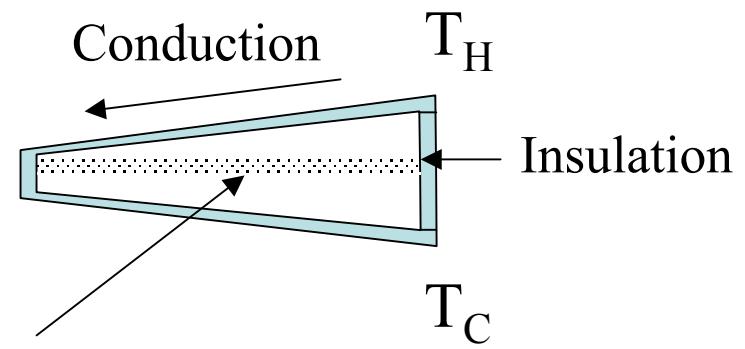


Continuous flow, transverse gradient CCN spectrometer

Aerosol Inlet



Aerosol Sample



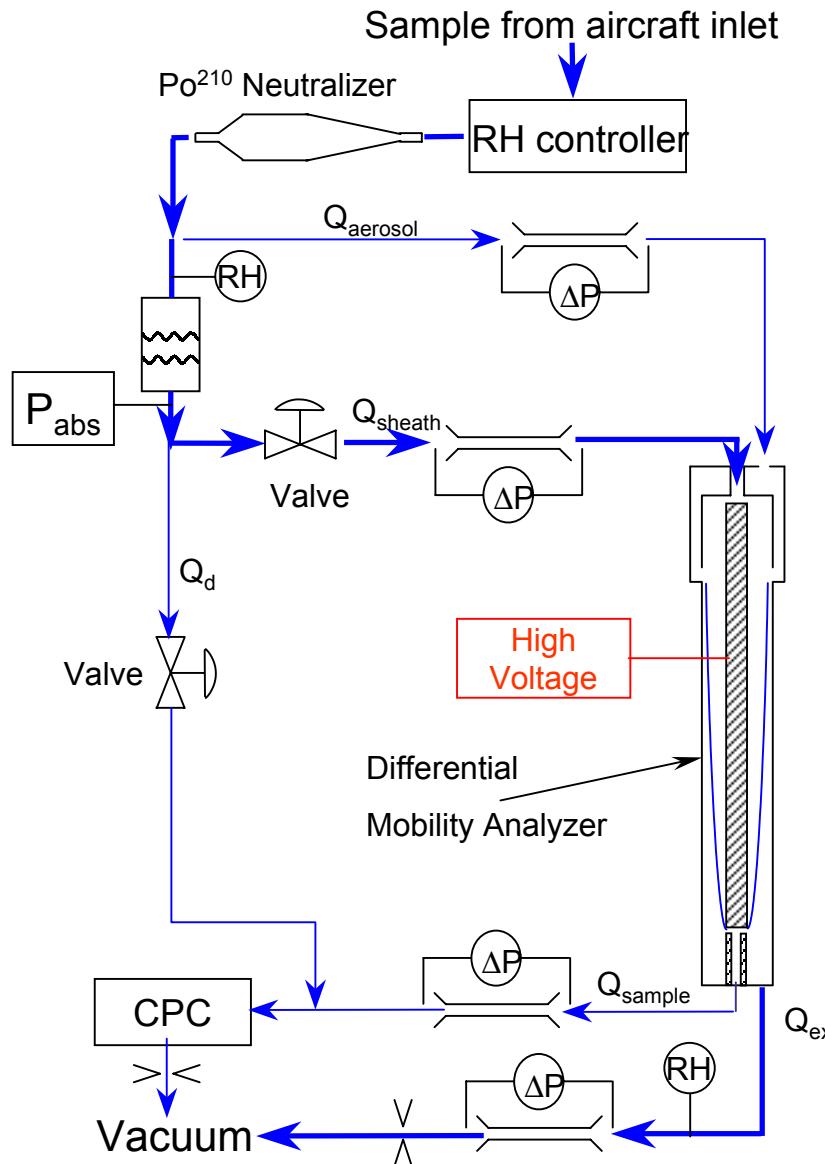
Aerosol Particle Size Distributions

- Electrical mobility:
 - SMPS (dry and ambient RH) (15 nm-1μm)
- Aerodynamic size
 - APS (0.8 - 10μm)
- Optical size
 - PCASP (0.1 - 3μm)
 - FSSP-100 (DMT Electronics) (1-50μm)
 - CAPS
 - CAS: 0.3 - 50μm
 - CIPS: 25 - 1400 μm)
- Kelvin size
 - CPCs (>2.5, >7, >9, >10.5 nm)

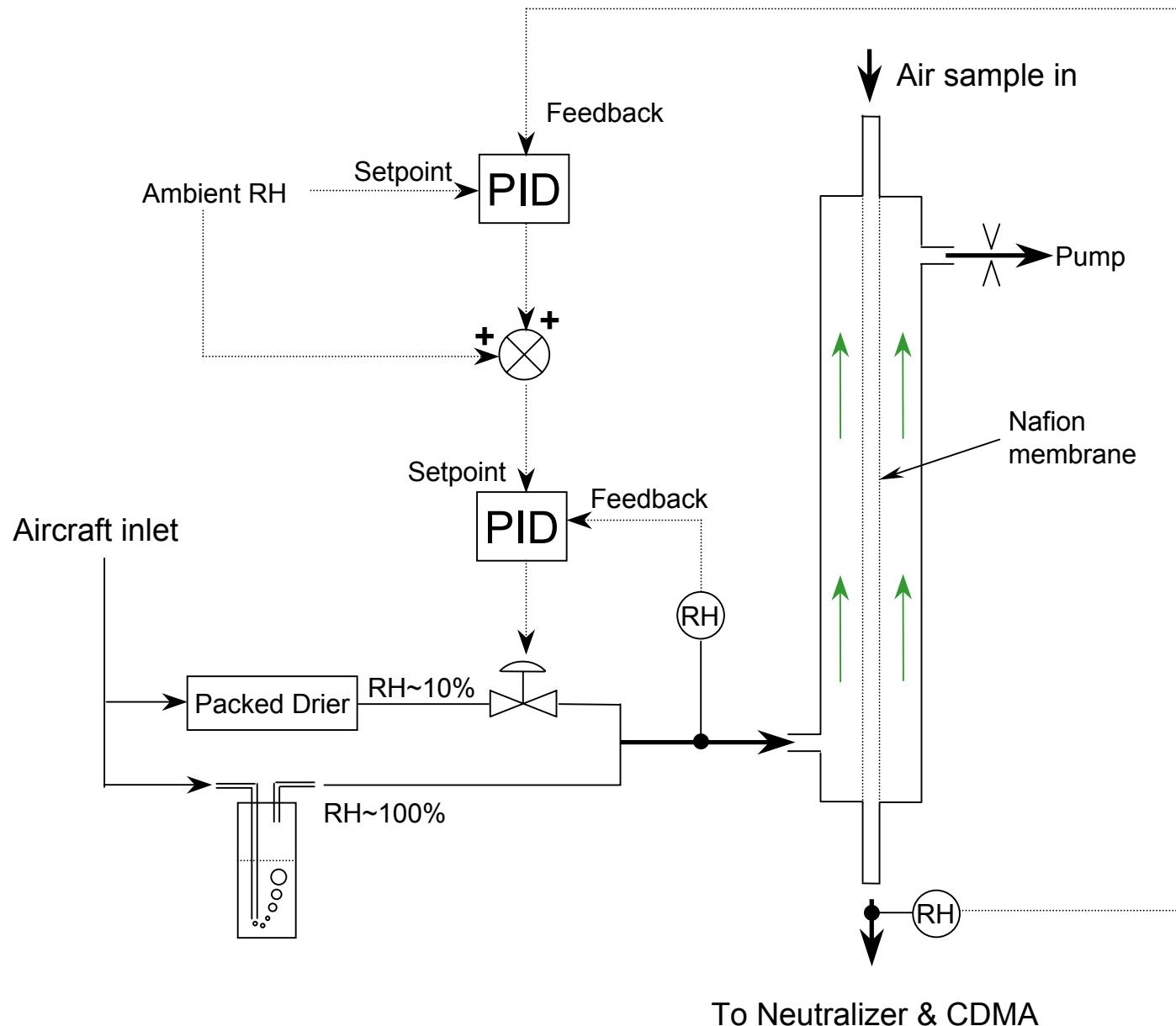
Caltech Dual Dry/Ambient SMPS System

- 2 DMAs operated in parallel
 - Dry (RH ~ 15%)
 - Ambient
(30% < RH < 85%, steady conditions)

DMA control system



RH controller



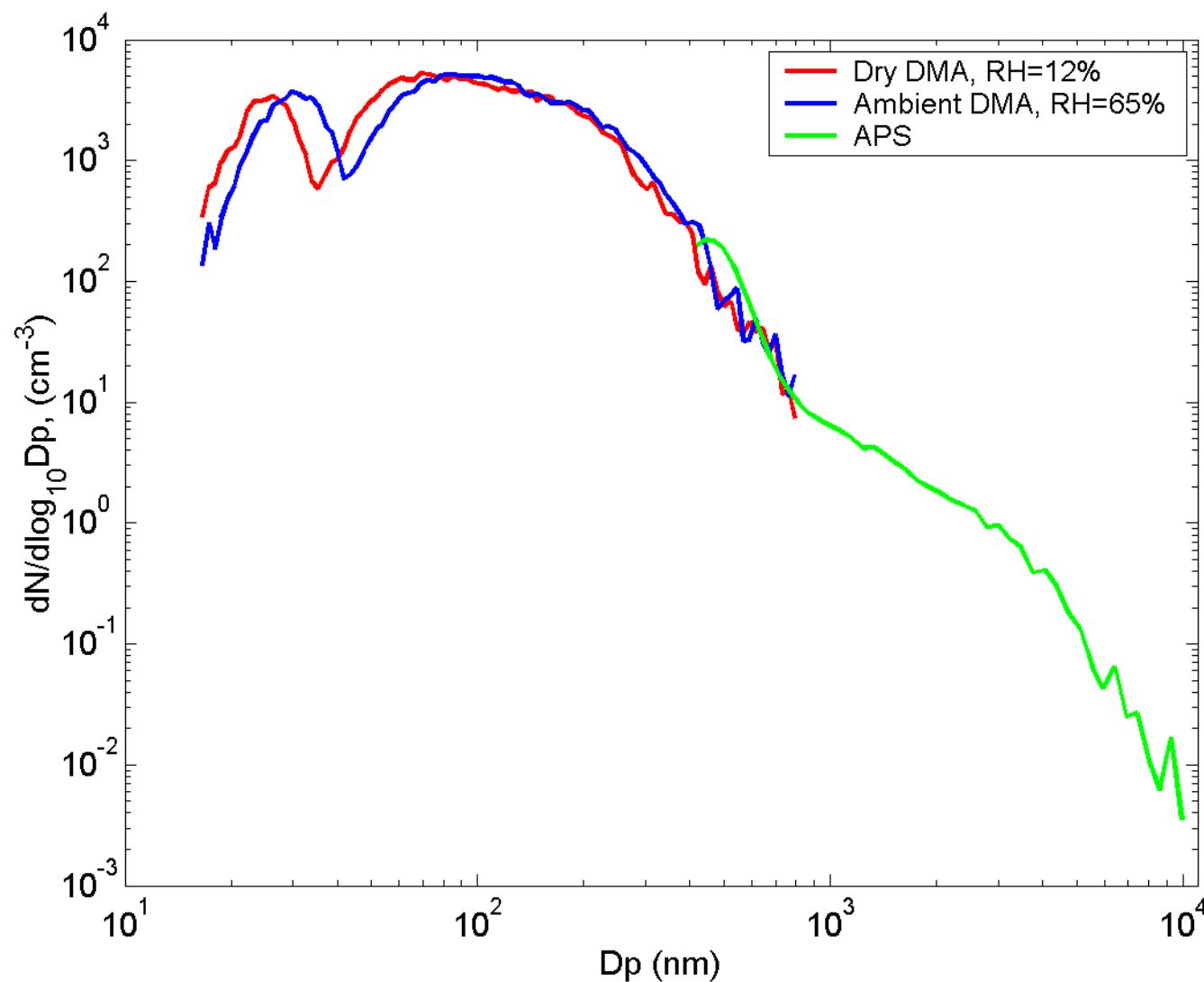
DMA Humidity Control in ACE-Asia

Aerodynamic Particle Sizer Wing-Pod Installation

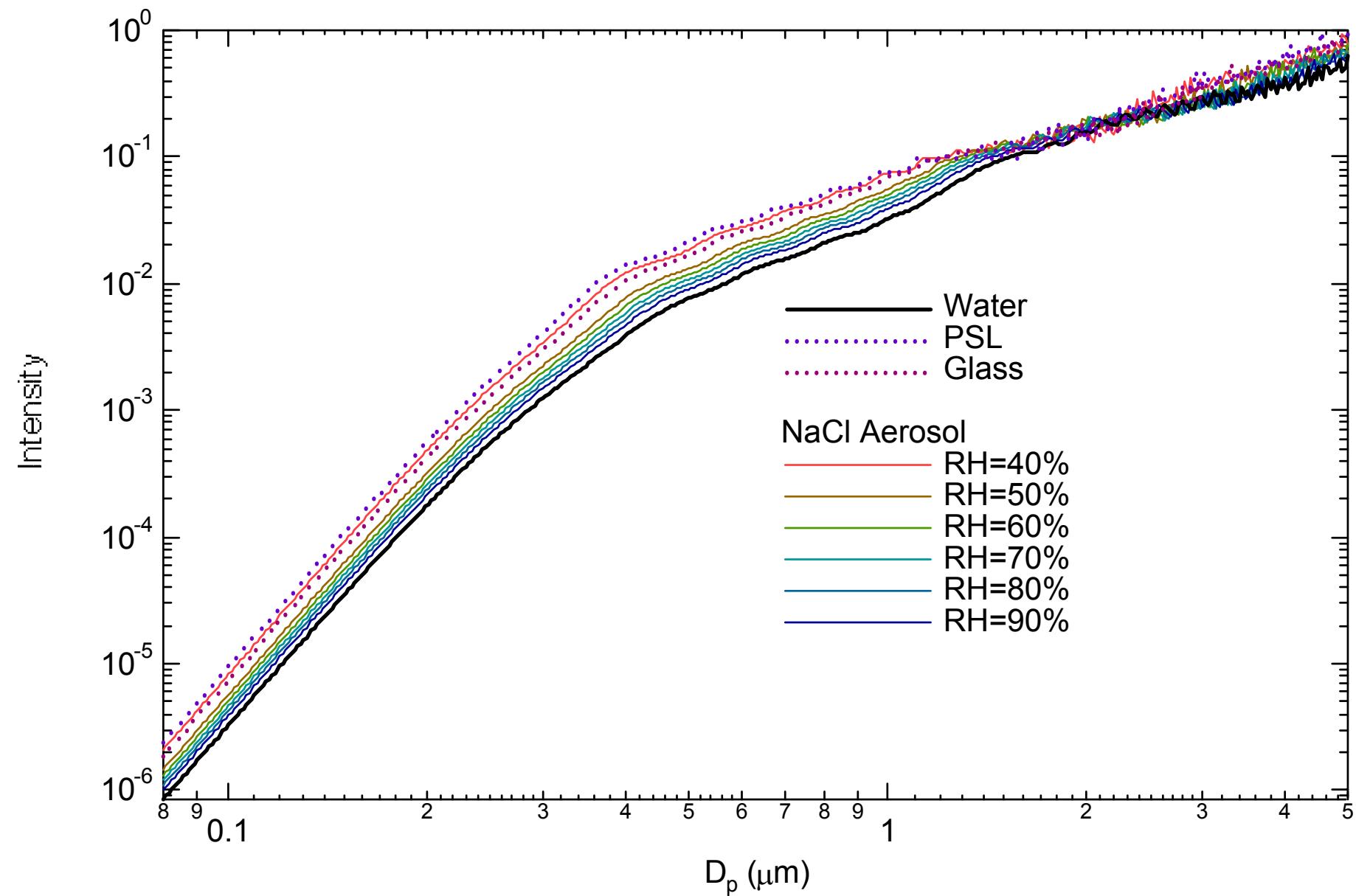
MOUDI Sampler and APS Pods

Twin Otter Sampling Probe

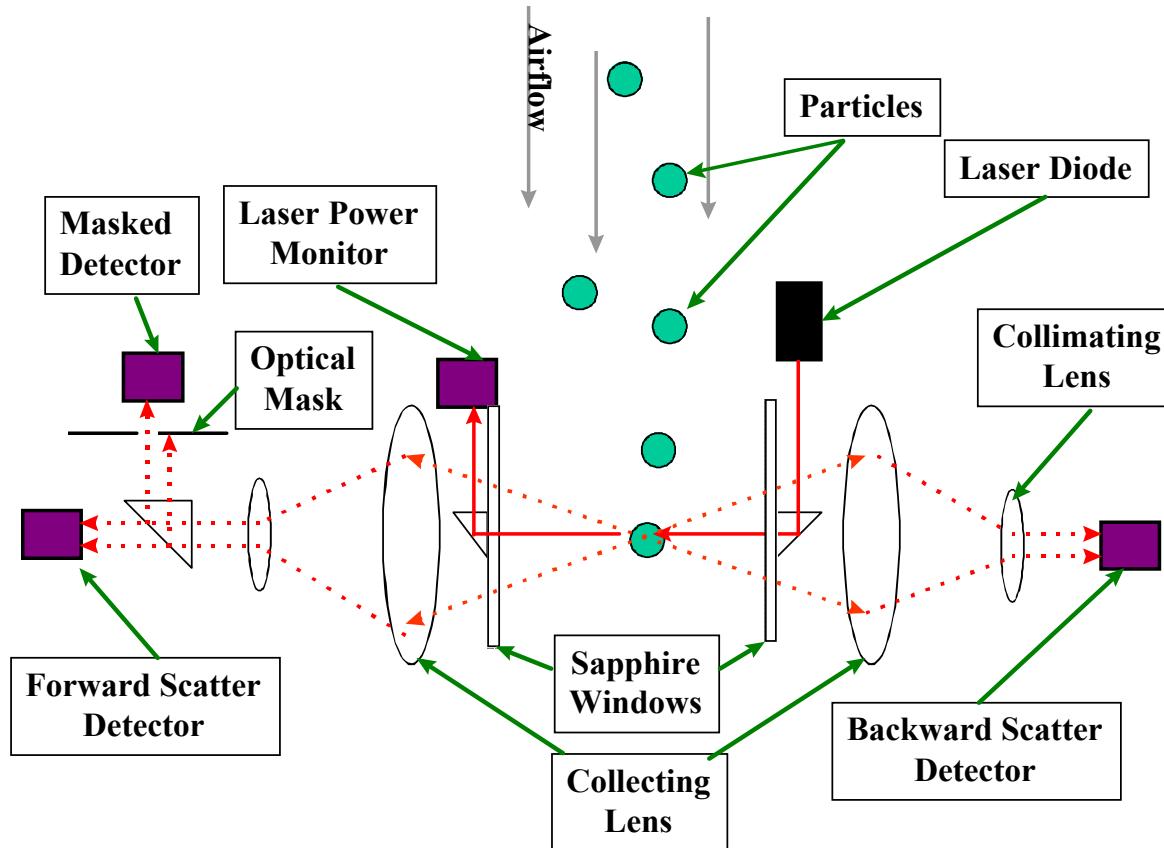
ACE-Asia, April 23rd 2001, southeast of Shikoku island.



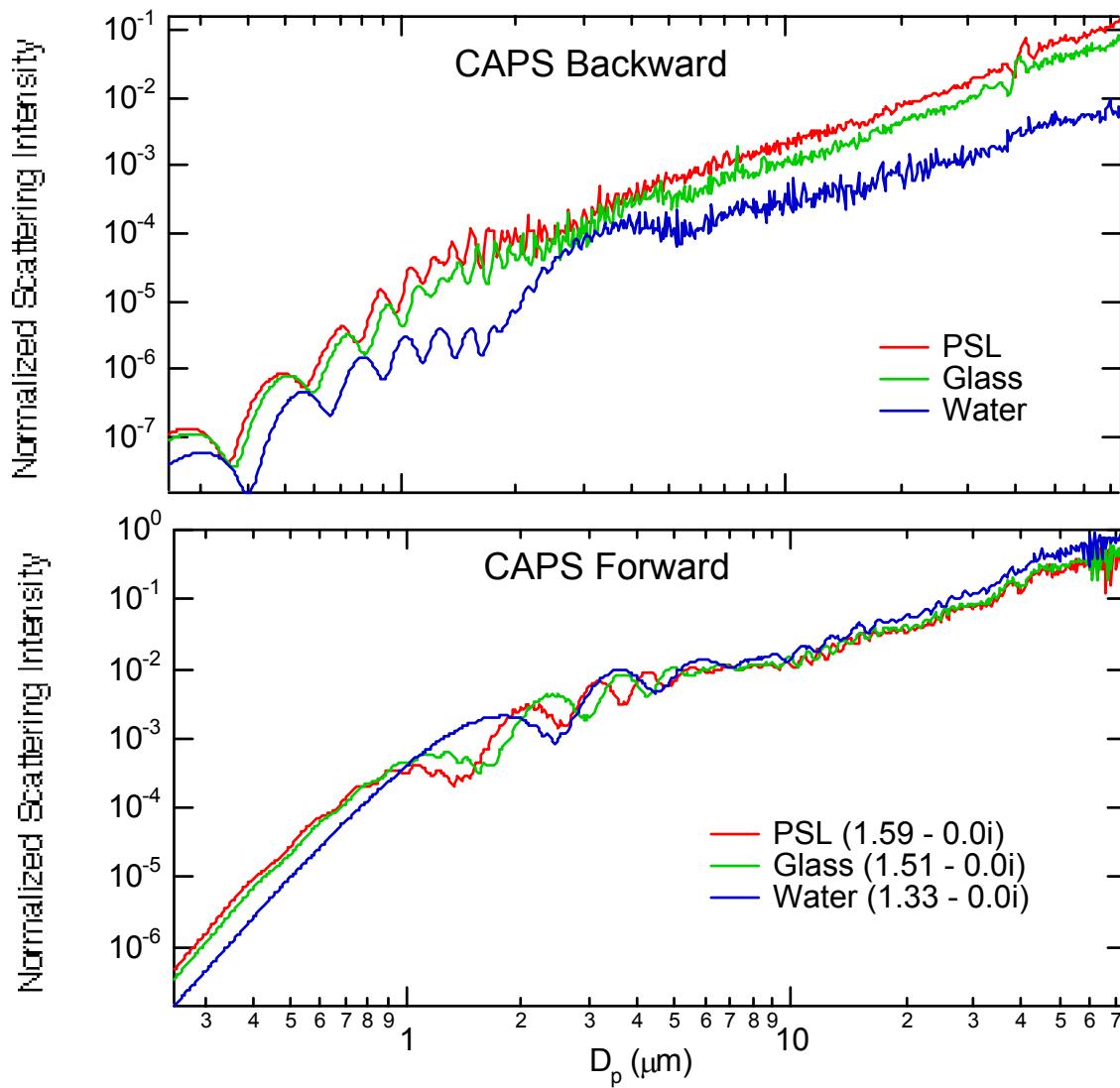
PCASP Response



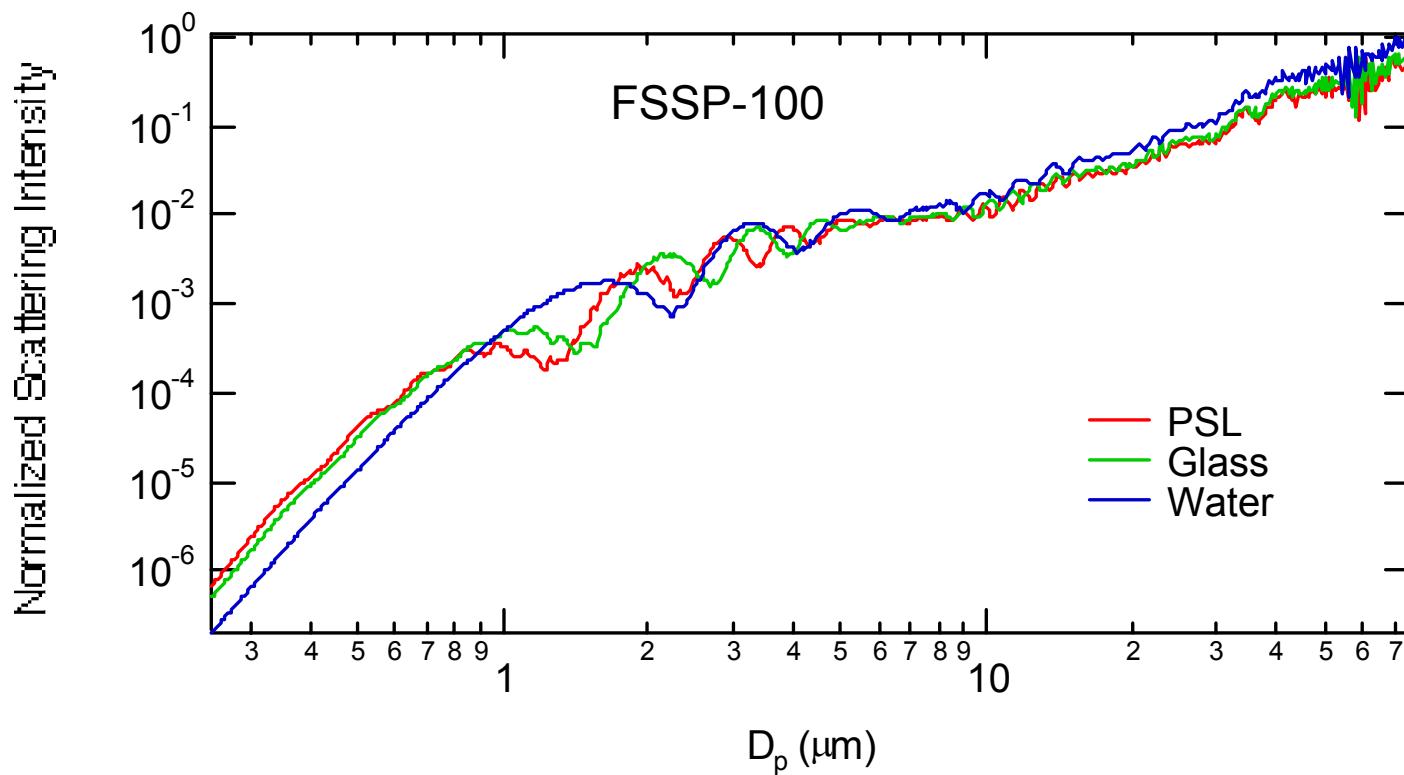
CAPS: Cloud/Aerosol Spectrometer (CAS) Forward and Back Scattering



CAPS Response



FSSP-100



Aerosol Chemistry

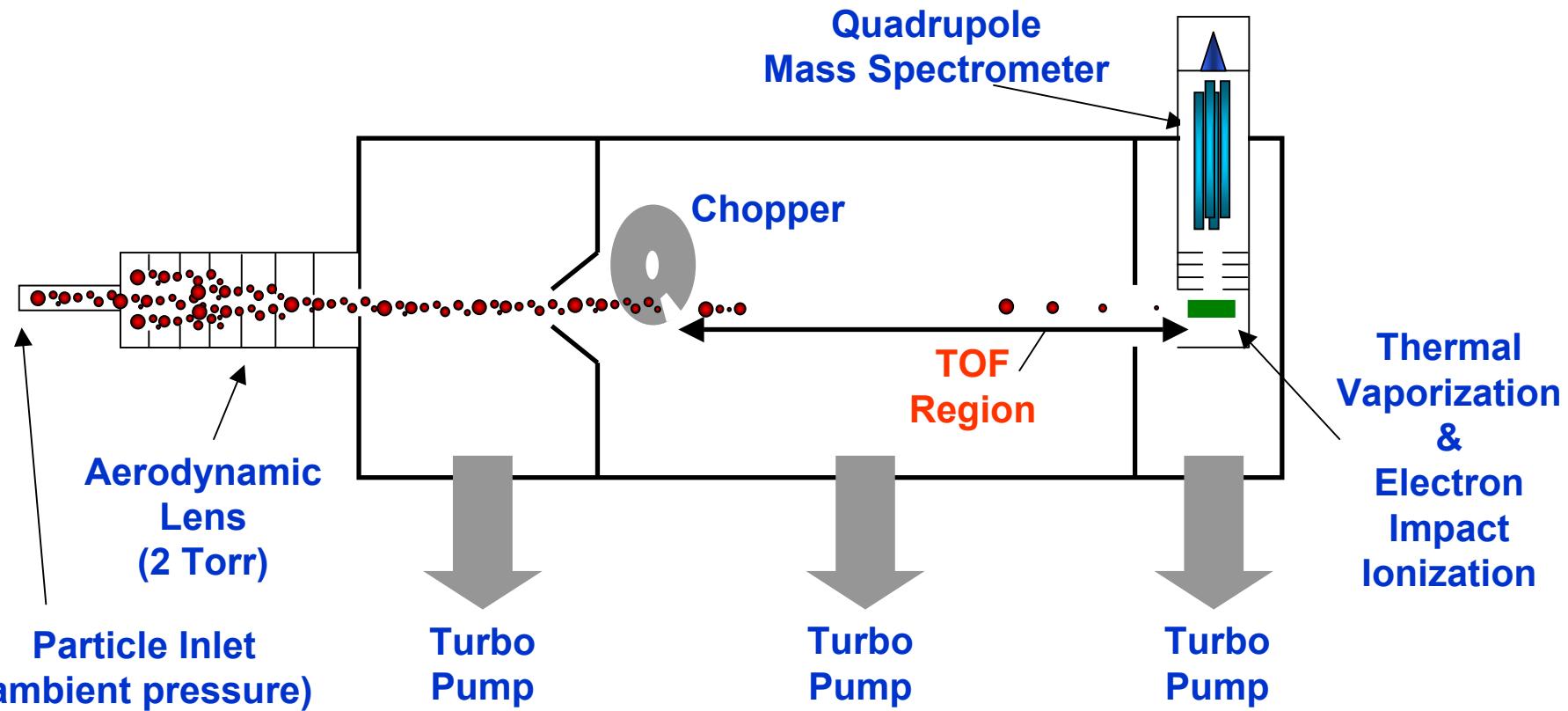
- Aerosol Mass Spectrometer
 - One ion per particle (not single particle analysis)
 - Size resolved composition distribution mode
 - 40nm - 5 μ m
 - Quantitative concentrations
 - Total aerosol composition mode
 - Quantitative total ion concentration
- MOUDI/Filter Sampler
 - 100 L/min
 - 0.25 - 3 μ m
- Multi-Sample Aerosol Collection System
(University of Denver)

Aerosol Mass Spectrometer (AMS)

Particle Beam Generation

Aerodynamic Sizing

Particle Composition

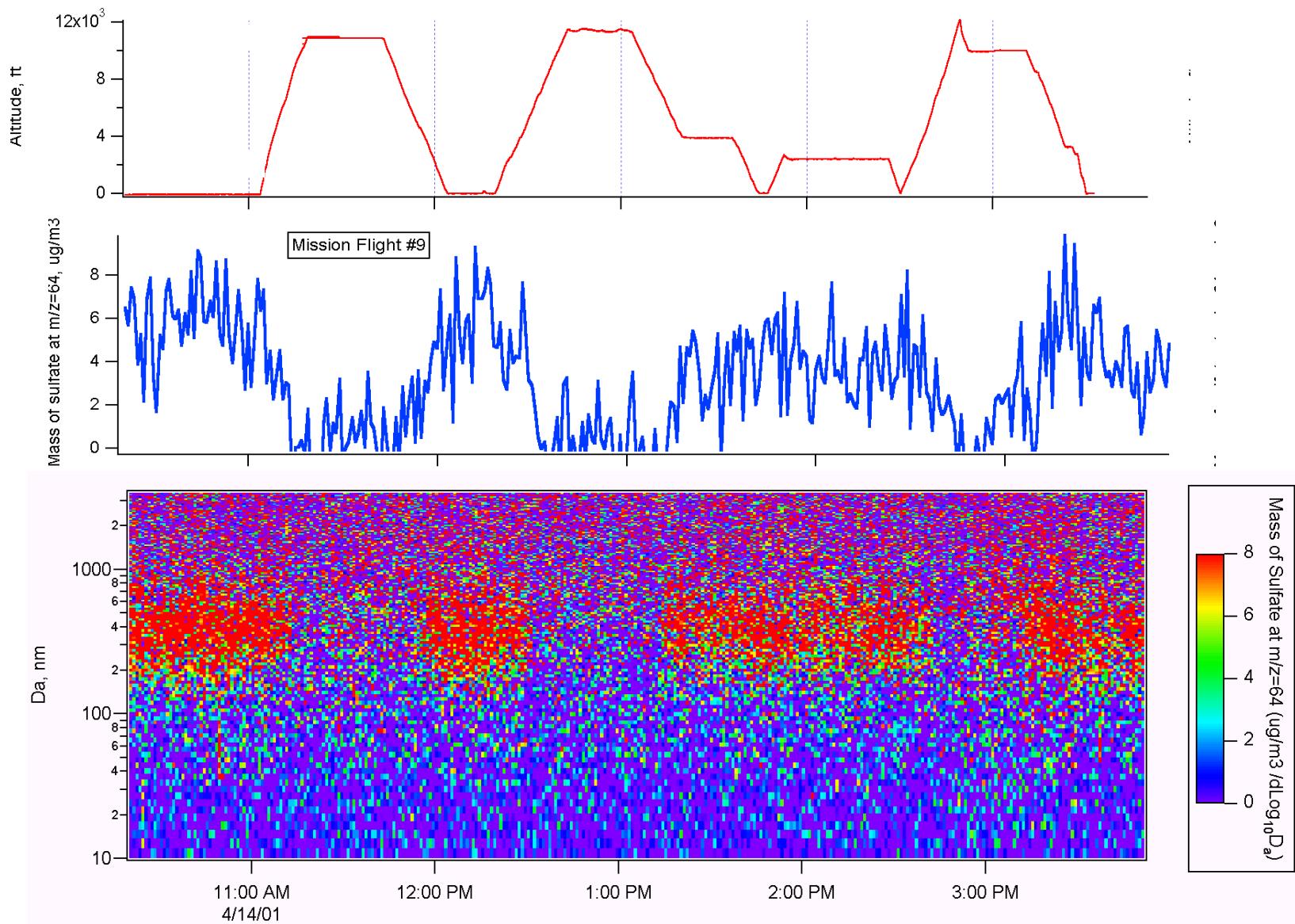


100% transmission (60-600 nm), aerodynamic sizing, linear mass signal.

Jayne et al., Aerosol Science and Technology 33:1-2(49-70), 2000.

Jimenez et al., Journal of Geophysical Research, submitted.

AMS SO_4 in Twin Otter RF #9



Estimated AMS averaging times for measurable signals (SNR = 10) for CRYSTAL-FACE

(v2, Jose L. Jimenez, Jan. 28, 2002)

Estimated averaging times for AMS (SNR = 10)	SO4	NH4	NO3	Organics	
Marine Boundary Layer, Conservative Scenario	11	31	19	26	min
Marine Boundary Layer, Most Optimistic Scenario	3	9	5	7	min
Free Troposphere, Conservative Scenario	21	55	41	36	min
Free Troposphere, Most Optimistic Scenario	6	15	11	10	min

Average concentrations (from data in Quinn et al., 1990; Huebert et al., 1996; Huebert et al. 1998)

	SO4	NH4	NO3	Organics	
Average concentration in Marine Boundary layer	1.06	0.20	0.36	0.50	ug/m ³
Average concentration in Marine Free Troposphere	0.31	0.07	0.08	0.25	ug/m ³

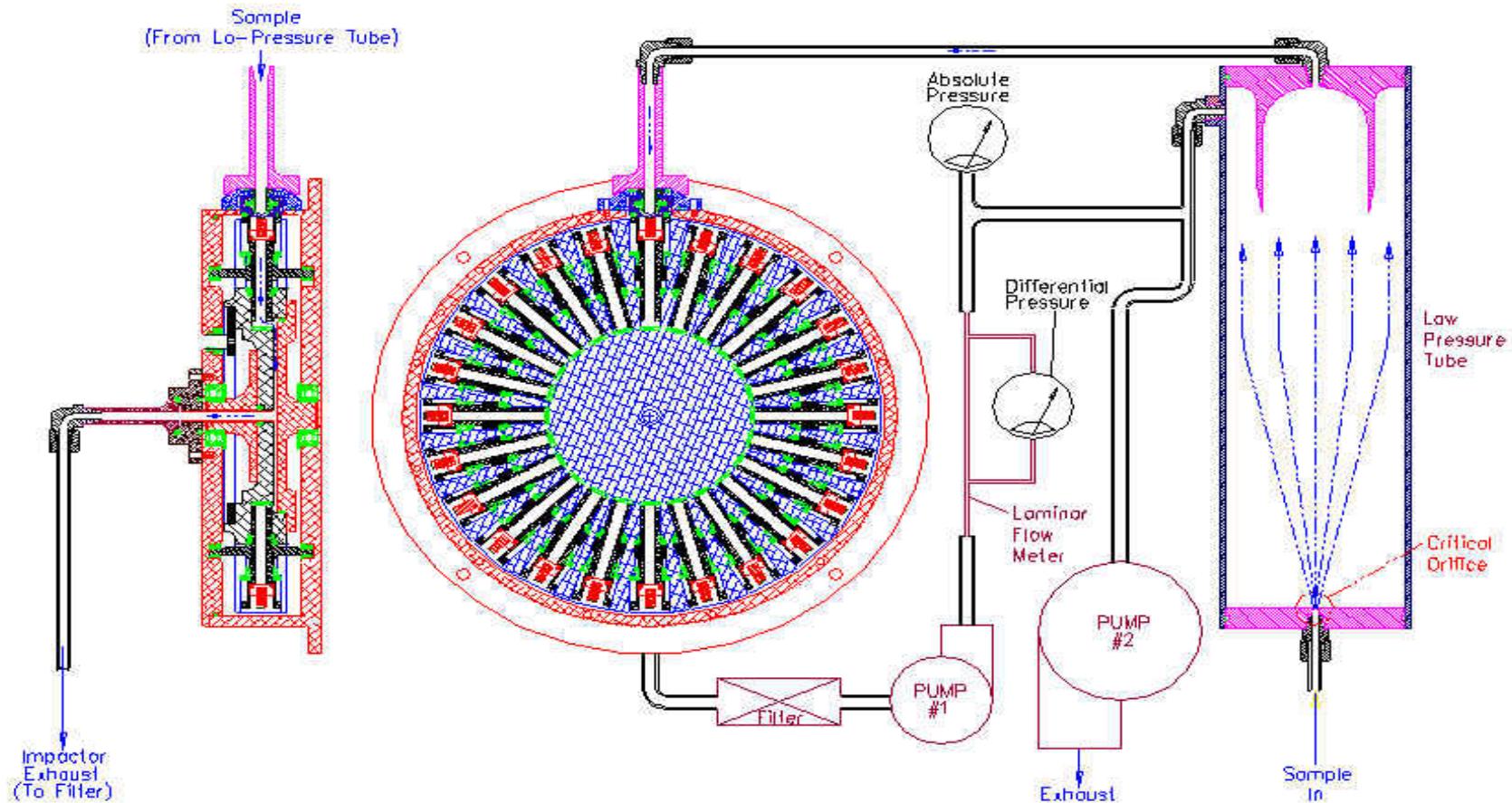
University of Denver

Multi-sample Aerosol Collection System

(MACS)

- Thin-plate, low-pressure impactor.
- Samples collected on electron microscope grids.
- Up to 24 samples/flight.
- 50% collection efficiency cut point at 20-40 nm diameter (may shift to larger D for C-F mission).
- Grids analyzed by Tomoko Kojima and Peter Buseck at Arizona State University, using TEM and associated techniques, for chemical composition, structure, and morphology.

DU MACS Schematic



Application to C-F Mission

- Help characterize the aerosol entering convective systems.
- Together with MACS on WB-57F, may provide information on cloud processing of aerosol, CCN.
- With CVI measurements on the Citation (C. Twohy), can estimate fraction of CN which are activated CCN.

High-Vol MOUDI Sampler

- 8 computer-controlled samplers/flight
- 5 μm precut
- MOUDI impactors: 2.5 μm , 1 μm , 0.7 μm , 0.5 μm , after-filter
- Total filter sample collection

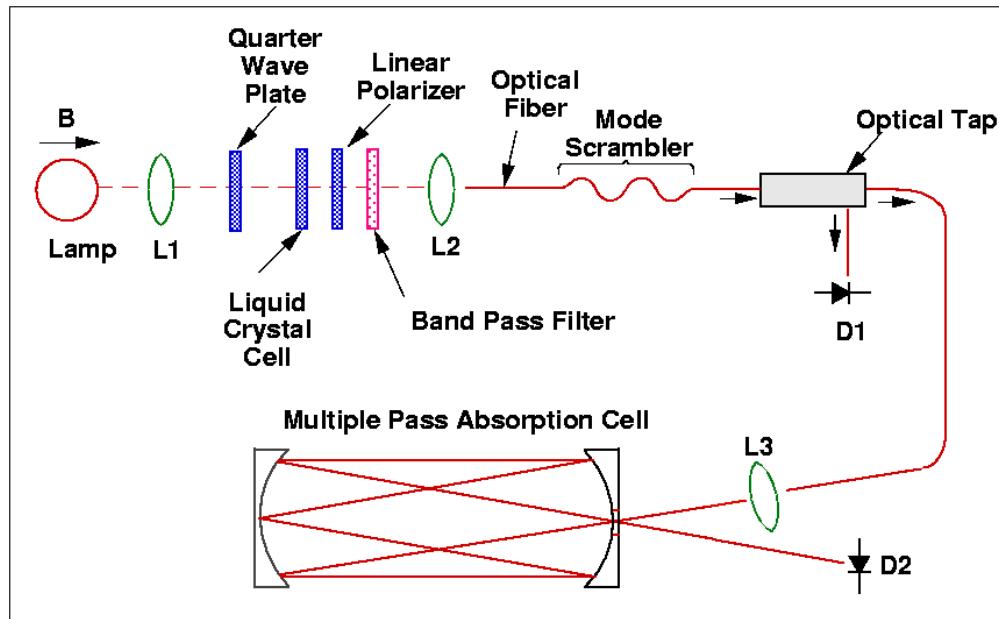
Fast Water Vapor Measurements

- Aerodyne Zeeman Line Splitting Differential Absorption

or

- NCAR Open-Path Tunable Diode Laser Absorption Hygrometer

Aerodyne Water Vapor



Temperature Range: 250-315 K

Pressure Range: 200-1200 mb

0.3-1.2 atm.

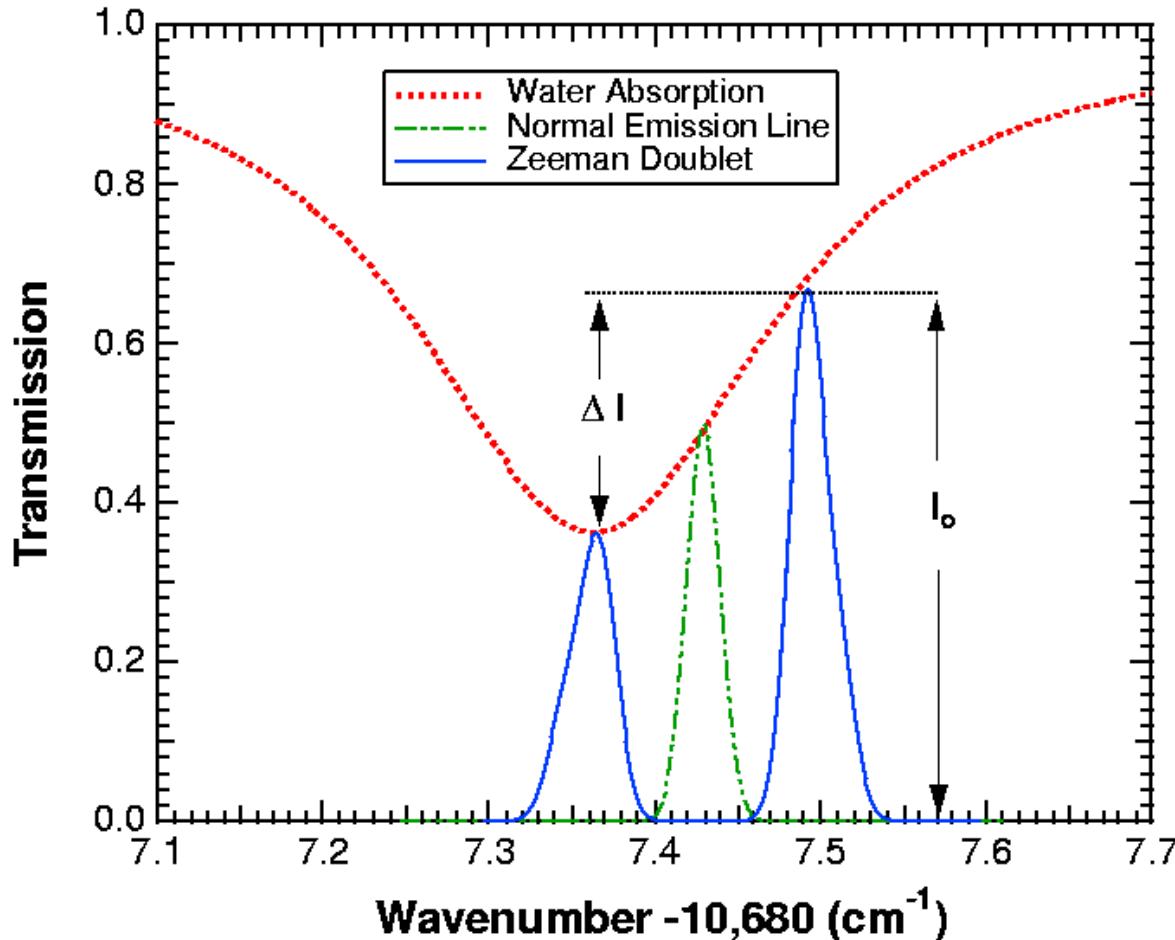
Sensitivity: 20 ppmv (at 1 Hz)

-55 °C Dew Point (1.0 atm.)

-65 °C Dew Point (0.3 atm.)

Time Response: 0.10 sec (0.01 possible)

Aerodyne Water Vapor *Operating Principle*



NCAR Open-Path Tunable Diode Laser Absorption Hygrometer



Path length (folded cavity):	19 cm
Linear Range:	0.005 - 20 g/kg
Accuracy:	< 4%
Sampling Rates:	
(std configuration)	1 Hz
(disjunct eddy sampling)	2.7 Hz
Weight (with mount plate):	20 lbs
Power:	4 A (28VDC)
Space for electronics (attached to mount plate):	5"x5"x6"

NCAR Resonance Fluorescence CO Analyzer



Linear Range:	3 ppbv - 100 ppmv
Detection Limit:	3 ppbv
Accuracy:	4 ppbv
Frequency Response:	3 Hz
Weight:	100 lbs.
Power:	2.6 A (28VDC) 3 A (60 Hz)
Space Requirement:	16 vertical inches
Support Gases (3 CL cylinders):	
Unit weight	25 lbs.
Unit size (dia x L)	7.25 x 21"

Solar Spectral Flux Radiometer (SSFR)

ARC Radiation Group: P. Pilewskie, W. Gore, M. Rabbette, L. Pezzolo, J. Pommier, S. Howard, R. Bergstrom

- wavelength range
300 nm to 1700 nm
- spectral resolution
8-12 nm
- simultaneous zenith and nadir viewing
- hemispheric FOV
- Accuracy: 3-5%; precision: 0.5%



TO Heritage
EOPACE Duck
(CIRPAS;1999)
ARESII (Sandia;2000)
ACE-Asia (CIRPAS;2001)



The ARM-UAV Pyrgeometer Sensor

- Modified by **Sandia National Laboratory** for Aircraft use
- Designed for high altitude and harsh environments
- Excellent dome/body thermal coupling
- Entire sensor tracks ambient air temperature
- Integrated miniature data system, RS-232 output
- Outputs Manufacture Serial number in data stream
- Platinum RTD temperature sensors for Repeatability and stability



Specifications:

- Modified Kipp & Zonen CG-4 Pyrgeometer
- Spectral Range: 4.5 to 42 μm
- Field of View: 180° field of view, good cosine response
- Temperature: -70C to +60C
- Power: +5VDC @ 50mA
- Weight: ~1 LBS.
- Dimensions: 2.9" Dia. X 2" H
- Data rates: DC to 10Hz
- Data output: RS-232, 20 bytes per measurement (Scan)
- Data system: 16 Bit, 4 Channel, Detector, Electronics and Case Temperature

